

The Application of the NeXus Format to Muon Data

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Or ...

A Common Format for Muon Data

Not the same thing ...

but perhaps the two things have
become confused!



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Outline

- The World of Muons
- A NeXus Definition for ISIS Muons
 - An early adopter
 - Where 'we' went wrong
 - The need for a new Version
- The way forward



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But avoiding a detailed description of
the Instrument Definition!

Latest Version can be Read at:

[http://www.nexusformat.org/Muon Time Differential](http://www.nexusformat.org/Muon_Time_Differential)



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The World of Muons



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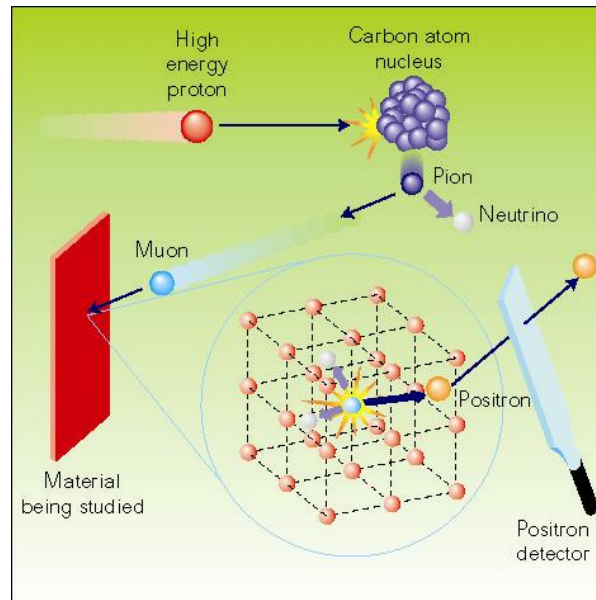
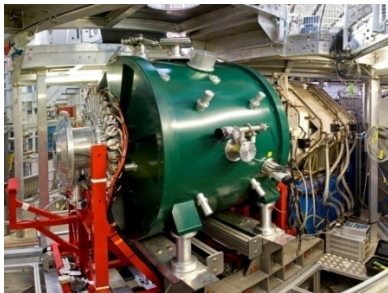
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Different to Neutrons and X-rays

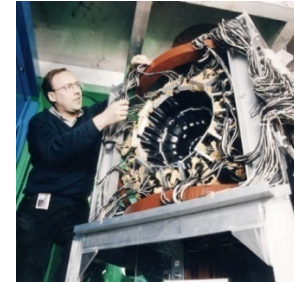
Muons ...

Travel in a beamline
from target to sample

Stop in the sample



Detect muon decay
products



**Generate lots of
'small' data files:**

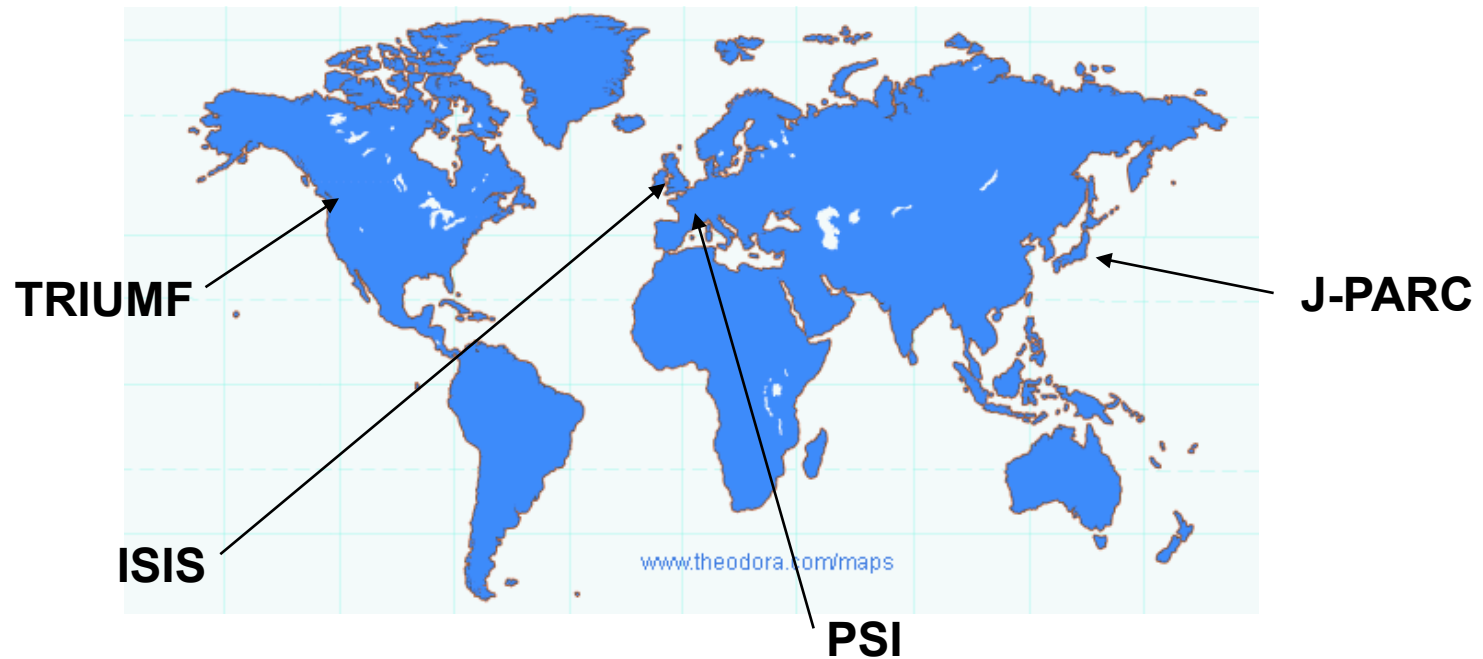
**<100 detectors \Rightarrow
~1Mbyte/run,
5-60mins/run**



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Four User Facilities



- Complementary ... Users work between facilities
- ~10% size of Neutron Community



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A Common Data Format?



Physica B 289-290 (2000) 722



Towards a single μ SR data format and common high quality user-facility analysis software

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Abstract

This round table discussion considered coordinating improvements in the portability and quality of μ SR analysis software. Panel members were Tanya Riseman, Ivan D. Reid (PSI), Steve P. Cottrell (ISIS), Jess H. Brewer (TRIUMF), and Mark Koennecke (PSI). Mark is a developer of the new neutron and X-ray scattering data format NeXus. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Data formats; Future developments

The round table panel members and audience considered two basic tactics. The first is to move towards a universal data format for all facilities. This might provide indirect improvement in software, because it will be much easier for both facility and 'private' software to be used with data from different facilities, with the better programs gaining more users. The second tactic is to concentrate on directly improving the analysis software.

For immediate hardware reasons, the first tactic was selected. Many of the new time-to-digital converters are incompatible with *all* pre-existing data formats. Data formats at PSI, ISIS and KEK are both archaic and extremely difficult to adapt to operating systems other than VMS, which is being phased out.

Mark Koennecke discussed how NeXus was chosen by the neutron scattering community: (see www.neutron.anl.gov/NeXus/NeXus.intro.html).

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NeXus is a data object/file definition in Hierarchical Data Format (HDF), which is a widely used, multi-platform, public domain data format.

The MUon Data (MUD) format presently used at TRIUMF is also a hierarchical data format, but implemented in C with FORTRAN bindings; (see <http://musr.physics.ubc.ca/mud/>).

Adaptations of NeXus and MUD are two obvious candidates for a universal μ SR data format. In favor of MUD, it is already in use at TRIUMF and is simple. In favor of NeXus, it is being actively developed at PSI and ISIS for the neutron community, and software such as HDF browsers and Open Genie already exist.

A data format task force was formed: Jess H. Brewer (TRIUMF), Steve P. Cottrell (ISIS), Wataru Higemoto (KEK), Ivan D. Reid (PSI), and Tanya M. Riseman (Univ. of Birmingham). A web site has been set up with a long write-up of the round table, the results of the round table's μ SR user survey and on-going discussion (<http://musr.physics.ubc.ca/fmts/>).

- Idea of a common data format was discussed at the 1999 μ SR conference
- PSI and ISIS formats archaic
- Existing MUD format and NeXus discussed
- Common Exchange Format?
- Data format task force formed
- Encouraged by the ISMS

But little progress ... why?



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A NeXus Instrument Definition for ISIS Muons



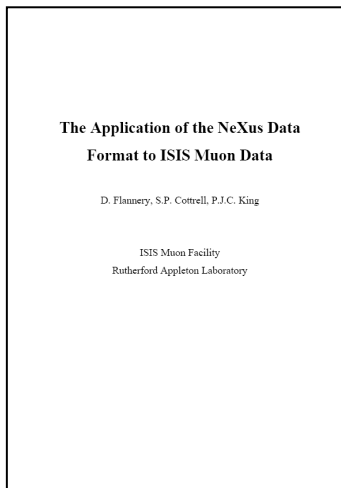
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ISIS Muons ... an early adopter

Student project:

- Instrument Definition (RAL-TR-2001-029)



Later:

Move from VMS to a PC-based DAE meant a new data format

NeXus was the obvious choice

Now have >65000 NeXus files!

- File converter (MCS→NeXus)
- Read routines
- Analysis programs
- ...



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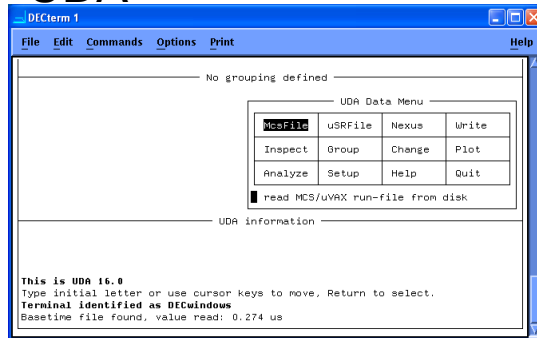
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Analysis Tools

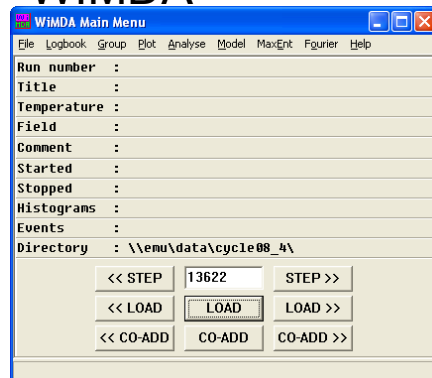
Using NeXus (and HDF) gave us access to lots of analysis tools:

Muon Specific ...

UDA

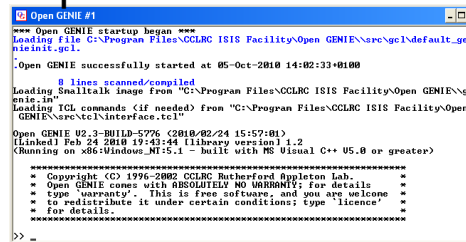


WIMDA

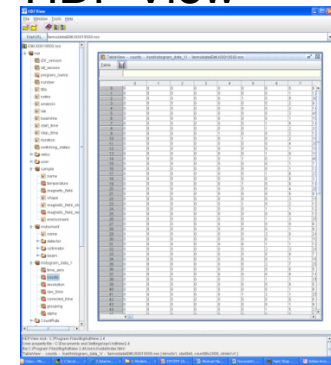


and Generic ...

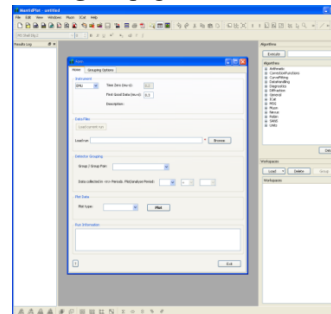
Open GENIE



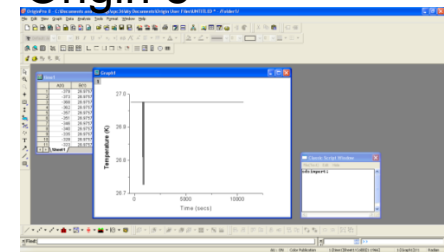
HDF View



Mantid



Origin 8



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Where 'we' went wrong ...

- I got some things wrong when writing the Definition
- NIAC evolved aspects of the NeXus recommendations (the Muon Definition preceded NIAC)
- Need to be closer to the ISIS Neutron Definition to simplify support for both DAE and analysis codes
- The Definition needed to be better able to adapt to new experiments and other muon sources



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A New Instrument Definition

Needed to answer these criticisms

Latest version at:

[http://www.nexusformat.org/Muon Time Differential](http://www.nexusformat.org/Muon_Time_Differential)

Not yet ratified, but getting close!

Improvements?



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Improved Metadata

Description of the muon beamline (for instance)

muon_beamline

RE	Name	Attribute	Type	Value	Description
	NXcollection				
1	beamline		NX_CHAR		name
0/1+	diagnostics		NXdiagnostics		container for any beamline diagnostic information.
0/1+	{beamline component}		NXdipole_magnet NXquadrupole_magnet NXsolenoid_magnet NXkicker NXseparator NXspinrotator NXbeamline_colimator NXseptum_magnet NXsteering_magnet		beamline components

Few entries are required, more can be added without breaking the format

RE	Name	Attribute	Type	Value	Description
	NXelectrostatic_kicker				component name
1	description		NX_CHAR		name
0/1	source_distance		NX_FLOAT		distance of flight path from production target
0/1		units	NX_CHAR	'metres'	
0/1	timing		NX_FLOAT		kicker timing, as defined by 'description' attribute
0/1		units	NX_CHAR	'nano.second'	
0/1		description	NX_CHAR		
0/1	set_voltage		NX_FLOAT		set value on PS
0/1		units	NX_CHAR		
0/1	read_voltage		NXlog		read from PS
0/1		units	NX_CHAR		
0/1	set_current		NX_FLOAT		set value on PS
0/1		units	NX_CHAR		
0/1	read_current		NXlog		read from PS
0/1		units	NX_CHAR		

electrostatic_separator

Metadata designed to link with beam simulation, e.g. TURTLE or GEANT



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Improved support for diagnostics

i.e. To determine where the experiment went wrong!

Easy to log and store parameters ... more metadata

runlogs (NXcollection)

RE	Name	Attribute	Type	Value	Description
	NXcollection				
To contain action and acquisition logs arising from activities of the data acquisition electronics (DAE) during the run – entries will be facility specific.					

selogs (NXcollection)

RE	Name	Attribute	Type	Value	Description
	NXcollection				
To contain sample environment logs arising from activities of the experiment control software – entries will be facility specific.					

Container classes:

runlogs: e.g. run start/stop, errors, etc

selogs: e.g. temperature, field vs. time

(NXlog's)

NXlog extended to log arrays



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Guidance for extending Definiton

Increasingly ... Experiments = 'Muons' + 'x',
where 'x' might be 'Light', 'E field', 'RF field', 'Humidity', ...

Can't define everything, so we've made recommendations

RE	Name	Attribute	Type	Value	Description
	rf_frequency		NX_FLOAT32	rf frequency	
		units	NX_CHAR	'MHz'	
		hardware	NX_CHAR	'marconi'	
		display_name	NX_CHAR	name displayed on DAE software	at , typically SECI block name
		software	NX_CHAR	version of driver used to collect data	at , typically VI name and version
	rf_delay		NX_FLOAT32	rf delay	relative to extract
		units	NX_CHAR	'us'	
		hardware	NX_CHAR	'stanford'	
		display_name	NX_CHAR	name displayed on DAE software	at , typically SECI block name
		software	NX_CHAR	version of driver used to collect data	at , typically VI name and version

Define new entries
(example for RF)

and location in file
(e.g. *selogs*)

Naming convention using prefix



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Improved Multi-period Support

NXdata

1 Stimulus ... 2 Periods

'RF on'
Memory 1

Switch every 'n' pulses

'RF off'
Memory 2

Twice as much data!

RE	Name	Attribute	Type	Value	Description
1	number				
1	type				
1	frames_request				
1					
0/1	output				
0/1	labels				
0/1					
0/1	raw_frames				
0/1	good_frames				
0/1	sequences				
0/1	counts				

RE	Name	Attribute	Type	Value	Description
1	counts		NX_INT[ns] NX_INT[ns][ntc] NX_INT[np][ns][ntc]	number of periods used function of period - DAO - 2 - DW	linked to detector counts in NXdetector
1	axes		NX_INT	'1'	frames collected in
1	axes		NX_CHAR	'[period_index, spectrum_index, raw_time]'	axes definitions
1	long_name		NX_CHAR	'positron counts' 'electron counts'	
0/1	raw_time		NX_FLOAT[ntc+1]	output bit pattern	linked to 'raw_time' in NXdetector
0/1	units		NX_CHAR	'micro.second'	
0/1	long_name		NX_CHAR	'time'	
0/1	spectrum_index		NX_INT[ns]	list of period names separated by char	linked to 'spectrum_index' in NXdetector (see Note 3)
0/1	long_name			'spectrum number'	
0/1	spectrum_labels			NX_CHAR - TBC	linked to semicolon separated list of spectrum names
0/1	period_index		NX_INT[np]	label list	link to 'period_index' in NXdetector
0/1	long_name		NX_CHAR	'period number'	
0/1	period_output		NX_INT[np]	good frames collected for each period	linked to 'period_output' in NXperiod - usually integer representing output bit pattern on period card
0/1	period_labels		NX_CHAR	counts collected in each periods	linked to semicolon separated list of period names

3D array

Axes

Period information

Store information about periods,
Link information from NXdata



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The Way Forward



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Why not a Common Format?

- Other Facilities perhaps lacked the motivation:
 - Happy with current formats (scientists see no benefit)
 - Moving to NeXus is resource intensive
 - Data formats are not that exciting!
- Revision of the ISIS Definition might have created doubt (in Muons) that NeXus is a useful standard:
 - NIAC needs to be cautious proposing changes to existing class definitions – don't break what's in place.
 - Need a balance: set the Definition quickly and carefully, but then don't touch it!
- Decisions, decisions:
 - Everyone has their own idea for the format!
 - Idea overload and disappointment



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But it's not all gloom!

- Revision of the Instrument Definition has been painful, but we've nearly finished ... then no more changes!
- EU Framework Programme 7 (under the Neutron and Muon I3) is stimulating EU wide adoption of NeXus (PSI and ISIS are close to agreeing a Definition)

'A detailed Nexus instrument definition file will be devised, suitable for both ISIS and PSI, which is suitable for capturing all instrument and beam parameters typically required for beam simulation.'

- Advanced instruments and analysis techniques (e.g. beam and instrument simulation) require better metadata – perhaps a compelling reason to switch?



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Conclusion

Idea for a
Common Data Format

*Can we
close the
loop?*

Stimulated

Muon Instrument Definition
(already useful to ISIS)



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Acknowledgements

- Thanks to Damian Flannery and Freddie Akeroyd who have done most of the coding, and Freddie for a lot of input to the new version of the Instrument Definition.
- Thanks to continued funding by the European Union under Framework Programmes 6 and 7 - enabling PSI and ISIS to work together on this project

Useful links:

[http://www.nexusformat.org/Muon Time Differential](http://www.nexusformat.org/Muon_Time_Differential)

<http://muons.neutron-eu.net/MuonsHome/>



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